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The J–2X Engine

NASA's New Upper Stage Engine

The J-2X engine is designed to be a highly efficient and versatile rocket engine and has the ideal thrust and performance characteristics to power the upper stage of a heavy-lift launch vehicle. The J-2X engine capitalizes on a half-century of human spaceflight experience coupled with state-of-the-art technology, design processes, and advances in material and manufacturing.

Capabilities

The J-2X will be powered by liquid hydrogen and liquid oxygen. With 294,000 pounds of thrust in its primary operating mode, the engine will be able to loft an upper stage into low-Earth orbit. By changing the mixture ratio of liquid oxygen to liquid hydrogen, the J-2X can operate in a secondary mode of 242,000 pounds of thrust required to power a spacecraft from low-Earth orbit to the moon, an asteroid or another celestial destination. The J-2X can stop and restart in space to support a variety of mission requirements.

The J-2X will measure approximately 185 inches long and 120 inches in diameter at the end of its nozzle. It will weigh approximately 5,450 pounds.

The J-2X uses a conventional gas generator cycle. The engine's gas generator is essentially a small rocket engine inside a larger rocket engine. It produces a large volume of hot gas that powers the engine's turbomachinery — the heart of the engine. The engine's turbomachinery consists of two turbopumps. Turbines provide the power to drive the pumps. One pump pushes high-pressure liquid oxygen, and the other pumps liquid hydrogen fuel through the engine and to the engine's main injector. When the two meet in the main combustion chamber, the fuels combine in controlled, high-pressure combustion. The resulting exhaust gas is directed by the engine's nozzle, producing the power needed to propel a launch vehicle to its journey to space.

Concept image of the J-2X engine. (NASA/MSFC)

As a technology demonstrator, a slightly modified J-2X could be a test-bed for a liquid oxygen-methane engine.

Heritage Design

The J-2X builds on the legacy of the Apollo-Saturn Program and relies on nearly a half-century of NASA spaceflight experience, heritage hardware and technological advances. The J-2X design is an evolved variation of two historic predecessors — the powerful J-2 upper stage engine that propelled the Apollo-era Saturn IB and Saturn V rockets to the moon in the 1960s and 1970s, and the J-2S, a simplified version of the J-2 developed and tested in the early 1970s but never flown.

The J-2X exemplifies NASA's engineering excellence using proven hardware and knowledge from 50 years of American spaceflight experience to streamline the hardware development process, and reduce program, technical and budget risks.

The J-2X engine will operate at much higher pressures and flow rates than the heritage J-2 engine to raise its performance from 230,000

pounds of thrust on the Saturn vehicles to 294,000 pounds on the contemporary launch vehicles. It will meet that goal by using new materials, and new scaled-up component designs.

Designs for the fuel and oxidizer turbopumps — the heart of the engine — are based on the J-2S engine developed in the early 1970s. The design has been enhanced, and modern manufacturing methods and materials will be used to meet current NASA design standards for greater performance and safety. The engine's gas generator, itself a small rocket engine that drives the turbopumps, is based on the design for the RS-68 engine now flown on the Delta IV rocket. The RS-68 also serves as the basis for the main propellant injector that controls flow into the main combustion chamber, and the main combustion chamber itself, where liquid hydrogen and oxygen are combined to produce thrust. The J-2X exhaust nozzle is cooled by its super-cooled fuels before they go to the main injector and main combustion chamber for combustion. A new nozzle extension, nearly 8 feet tall and 10 feet in diameter at its opening, enabling the engine to meet higher operating efficiency requirements, which in rocket engine design is essentially miles per gallon.

Testing, Manufacturing and Operations

Component testing was essential to the development of the J-2X engine. The use of heritage J-2 hardware allowed NASA to begin early testing in 2006 to better understand its performance. Both full-scale and subscale heritage J-2 turbopumps, gas generators and other key components have undergone rigorous testing at facilities around the country to understand the design issues involved in raising performance. Following this heritage hardware testing,

A battery of tests conducted on the J-2X workhorse gas generator at the Marshall Center validated the new design.

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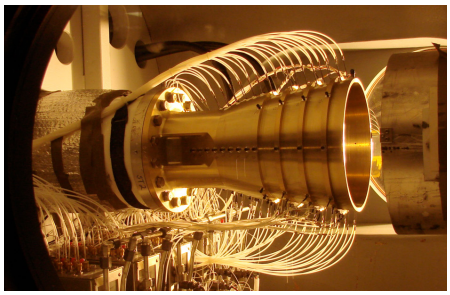

Engineers at the Marshall Center conducted more than 1,000 J-2X nozzle start simulations beginning in March 2008. (NASA/MSFC)

NASA also extensively tested J-2X components, including the full-scale gas generator, turbopump subscale parts and full-scale assemblies, flex ducts, igniters, electronic controller, valves and actuators.

A variety of existing test facilities support development of the J-2X, including some previously used to test the space shuttle main engine and the Saturn-era engines before that. NASA turned over the A-1 test stand at the John C. Stennis Space Center near Bay St. Louis, Miss., to the J-2X program in 2006. It was refurbished and supported heritage J-2S turbopump development testing in 2007 and 2008. The Stennis A-2 test stand was transferred from the shuttle to the J-2X project in 2010. NASA also broke ground in 2007 for a new test stand, designated A-3, at Stennis. It will be used to test engine operation at altitudes simulating the vacuum of space. The new stand will be ready in 2013.

Benefits

By using current, state-of-the-art engine technologies and drawing on the heritage and knowledge of the J-2 and J-2S engines, NASA engineers delivered a safe and more cost-effective engine. This combination of advanced and proven hardware will reduce development, manufacturing and operations costs for the J-2X. In addition, J-2X design improvements over the heritage designs enable higher engine performance to meet mission requirements for NASA's future exploration missions.

The J-2X is designed and built by Pratt & Whitney Rocketdyne of Canoga Park, Calif., for NASA's Marshall Space Flight Center in Huntsville, Ala.

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